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Modification of Selected Integrated Sight Unit Controls on the Bradley Fighting Vehicle

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Stephen D. Knapp, and David L. Lewis
Litton Computer Services Division
Litton Systems, Inc.

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The design of the contrast, brightness, and on/off controls of the Bradley Fighting Vehicle's (BFV's) thermal sight has resulted in frequent accidental displacement of setting. As this report shows, such accidental displacements delay and inhibit a gunner's ability to classify and engage targets. A solution to this problem has been experimentally tested. The contrast and brightness knobs had vinyl grommets inserted between the knobs and the panel face. The grommets provide sufficient friction to make accidental displacement unlikely. A guard was added to the on/off control to make accidental switching of the sight less probable.

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FOREWORD

Since 1975 the Army Research Institute for the Behavioral and Social Sciences (ARI) has contributed to a program to define emerging problems and address critical issues affecting the Bradley Fighting Vehicle (BFV). Consistent with that program, this report describes a method of modifying selected thermal sight controls to avoid inadvertent missetting. It is expected that this modification will improve the combat capability of the BFV.

ARI's Fort Benning Field Unit, a division of the Training Research Laboratory, monitored this research. ARI's mission is to conduct research of training and training technology using infantry combat systems and problems as mediums. The research task that supports this mission, 3.4.2., "Advanced Methods and Systems for Fighting Vehicle Training," is organized under the "Train the Force" program area. Sponsorship for this research effort is provided by a Memorandum of Understanding (effective 31 May 1983) between the U.S. Army Infantry School (USAIS), Training and Doctrine Command (TRADOC), Training Technology Agency, and ARI, which established how joint efforts to improve BFV tactical doctrine, unit, and gunnery training would proceed.

Feedback from frequent in-process reviews and briefings to USAIS and its instructors suggests that the research projects reported here will improve the capabilities of the BFV and its personnel.

Edgar M. Johnson

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Technical Director

MODIFICATION OF SELECTED INTEGRATED SIGHT UNIT CONTROLS ON THE BRADLEY FIGHTING VEHICLE

EXECUTIVE SUMMARY

Requirement:

Litton Computer Services operated under contract to and with guidance from the Army Research Institute for the Behavioral and Social Sciences (ARI) at Fort Benning, Georgia. Litton's researchers investigated the operational parameters of the thermal sight and developed techniques that would enhance the performance of Bradley Fighting Vehicle (BFV) gunners using the thermal sight.

Procedure:

Observation of BFV gunners revealed a shortcoming in the design of the contrast and brightness knobs and on/off switch of the thermal sight. The contrast and brightness knobs rotated so freely that they were easily and frequently displaced from their settings. The on/off control was unguarded and therefore also subject to accidental switching. Alternative solutions were considered that were simple and inexpensive to implement. An optimum solution was identified and tested on a vehicle.

Findings:

For the contrast and brightness knobs, the insertion of a small vinyl grommet between the knob and the panel face provided sufficient friction to make accidental displacement unlikely. The addition of a small half-guard above and to the left of the on/off switch prevented accidental displacement by vertical or lateral hand movements. The solutions were verified in an experiment using 16 BFV personnel.

Utilization of Findings:

The implementation of these two simple modifications will facilitate the thermal acquisition and engagement of targets. Gunners will no longer, on occasion, accidentally turn off the on/off switch of the sight when reaching up to change magnification or focus and they will no longer have to readjust the contrast and brightness knobs when their lateral hand movements catch and displace these controls.

MODIFICATION OF SELECTED INTEGRATED SIGHT UNIT CONTROLS ON THE BRADLEY FIGHTING VEHICLE

CONTENTS

LIST OF FIGURES

MOᵀIFICATION OF SELECTED INTEGRATED SIGHT UNIT CONTROLS ON THE BRADLEY FIGHTING VEHICLE

INTRODUCTION

A Bradley Fighting Vehicle (BFV) gunner's ability to maintain a usable thermal image is critical to detecting and engaging the enemy at night and in limited visibility conditions. During thermal experiments (Rollier, et al., 1988; Rollier, Knapp, Frederick, & Champion, 1988), researchers noted that BFV gunners often have difficulty achieving and maintaining a tactically usable thermal image on the integrated sight unit (ISU). Observation showed that this problem is caused in part by drawbacks in the design and layout of the ISU controls.

The researchers were constrained in the degree of intervention they could make because BFVs are already fielded and the design of the ISU is essentially fixed. Therefore, investigations were limited to control modifications where simple, inexpensive solutions appeared feasible.

The one part of the ISU control panel that is suitable for such modification is a small sub-panel located on the lower left section of the ISU. This sub-panel comprises four controls arranged side by side. These are the polarity switch, the brightness knob, the contrast knob, and the three-position switch that turns the night sight power on and off and also activates a small thermal lamp on the outside of the vehicle that is used for boresighting. There are a number of problems with these controls. In seeking solutions to these problems, the researchers recognized a number of constraints. These were that the proposed modifications should not require going behind the ISU control panel, should be easily and quickly performable by minimally trained personnel, and should be inexpensive.

Night Sight Power/Boresight Switch

This three-position switch turns the thermal sight on when it is switched to the up position, turns the thermal sight off in the central position, and turns the external boresight lamp on in the down position (the lamp is used to boresight the thermal sights of BFVs). The switch does not lock in position and is not safeguarded. For this reason, it is vulnerable to accidental changes of setting when the gunner makes vertical hand movements to change magnification or adjust focus. Turning the thermal sight off or the external thermal lamp on accidentally when in action would be undesirable. Turning the sight off blinds (if only momentarily) the BFV gunner. Turning the thermal lamp on provides a thermal signature independent of any other heat generating source and makes it an easier target for the enemy to detect.

Contrast and Brightness Controls

The brightness and contrast knobs are both small, 1/2-inch diameter, rotary controls with an 11/16-inch clearance between them. Both knobs rotate freely. The problem is that the knobs are too close together; minimum clearance between the knobs should be a minimum of 1 inch and optimally 2 inches to allow for operations in which gunners wear gloves or protective clothing (Diffrient, Tilley & Harman, 1981). Because there is insufficient clearance, rotating one of the knobs can lead to the inadvertent counter-rotation of the other. In addition, the free rotation of these two controls means that lateral hand movements, such as occur when the gunner moves his hand across to switch sight polarity, can lead to fingers brushing the tops of these controls and mis-setting them. Finally, on occasions, the vibration arising from vehicular movement can cause these controls to move from the desired setting.

When a gunner has detected a thermal anomaly (potential target) and is trying to determine its nature and military significance, he may change the thermal sight polarity setting several times. This is because black hot polarity brings out the shape of the target, whereas white hot allows him to see the position of hot areas within the target shape. For a vehicular target that has been moving, these hot areas would include engine, exhaust, and road wheels. Concurrently, the gunner will be making fine adjustments to the focus, contrast, and brightness knobs in order to obtain the clearest possible image. Accidental displacement of control settings at such a time is distracting and will delay the gunner in his determination of the nature of the target. In combat, such delay is undesirable and may be fatal.

Polarity Switch

Although the polarity switch is also subject to accidental switching, in the same way as the night sight on/off switch, the researchers determined that no guard was needed. There are two reasons for this. First, when classifying a target, gunners often find it desirable to repeatedly switch polarity and would not want to be hampered by a guard. Second, the accidental switching of polarity entails no loss of acquired target, and therefore constitutes no risk to the vehicle.

METHOD

Modification of the Contrast and Brightness Knobs

Since the knob positions cannot be changed to give greater separation and clearance between them, an alternative solution lies in limiting the freedom with which the contrast and brightness knobs rotate. The researchers tried two methods. The first involved replacing the existing knobs with push-in-to-turn knobs. Initial testing on a mock-up of the sub-panel destroyed two varieties of this knob in a remarkably short time. The second method proved to be both durable and successful. This involved inserting a vinyl grommet between each knob and the panel face (Figure 1). The grommets provide friction so that the freedom of rotation of the knobs is much reduced, making accidental displacement more difficult.

The method of installation is simple: Loosen the two set screws (1/16-inch or 3/32-inch, depending on the vehicle) that hold the knob to its shaft, using an allen wrench; remove the knob; fit the grommet onto the shaft; replace the knob; press firmly down on the knob face so that the grommet is compressed, and tighten the set screws into place. The degree of friction provided by the grommet is variable with the degree to which the grommet is compressed when the knob is tightened down. The grommets used were 5/16-inch, the same diameter as the inside diameter of the knob, and fit snugly onto the knob skirt. The grommets were produced by the Tandy Corporation for Radio Shack (catalogue number 64-3025).

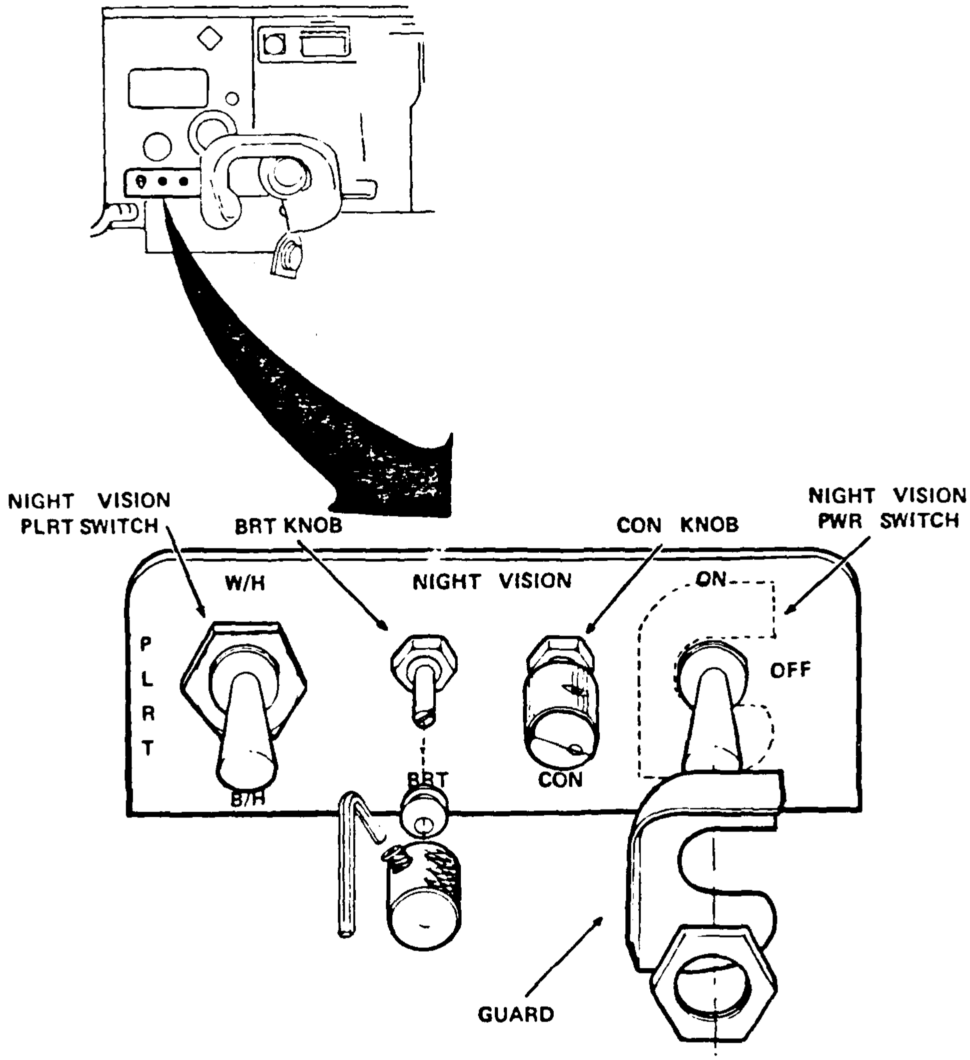

Figure 1. Illustration of Integrated Sight Unit (ISU) Sub-panel Modification.

As a simple test to ensure that low temperature did not alter the effectiveness of the grommet, a modified knob on a mock-up panel was placed in a freezer for 48 hours. Apart from a slight increase in stiffness of rotation, no changes were found. A second grommet was placed loose in the freezer for 24 hours, and then tested for brittleness by subjecting it to a sharp twisting action. Again, apart from an increase in resistance to the twisting action, no splits, tears, or other damage was found; and the grommet regained its normal degree of resilience in less than three minutes.

The on-vehicle test of the modification took place when temperatures were in the high nineties (degrees fahrenheit). No degradation in the ability of the grommet to provide friction was found. Clearly, these tests are not definitive; they are merely indicative that the solution may be viable. Precise laboratory testing would be required to define temperature performance limits for the grommets.

Modification of the Night Sight Power/Boresight Switch

A guard, or a locking switch, or a change to a detent rotary control is required to preclude instances where the night sight power/boresight switch is turned off or the external thermal lamp on. In developing a solution to the problem, the researchers kept in mind the constraint against going behind the ISU control panel. Effectively, this meant not changing the existing switch or drilling the panel front to fit a guard. Therefore, a guard was fitted by using the locking nut on the switch itself to hold it in position. The problem analysis had shown that the principal risk lay in accidentally moving the switch downward, i.e., turning the thermal sight off, or the boresight lamp on. Upward movements would either turn the boresight lamp off (which may be annoying during boresighting procedures but incurs no risk) or it would turn the night sight on so that it begins to cool down ready for use. (Again, no risk to the survival of the vehicle is entailed.) Other considerations included ensuring sufficient access space to the switch so that it could be used by a gunner wearing heavy gloves and forcing the gunner to lift his hand a little after turning on the night sight so that he did not accidentally brush other controls that might have been set from previous use.

The researchers designed an open-faced metal guard with a one-inch lip jutting out above and to the left of the switch (Figure 1). This guarded against downward vertical hand movements and lateral movements toward or away from the contrast, brightness, and polarity controls. A prototype was cut out of thin sheet metal and was fitted to the modified ISU panel.

Experimental Procedure

Two BFVs were used. One had the contrast and brightness knobs modified as described above; the other had unmodified controls. Sixteen subjects with experience in using the thermal sight were asked to test both sets of controls, and their opinions were recorded. The subjects ranged in rank from E4 to E6 (Gunner to Squad Leader/Platoon Sergeant). Thirteen of the sixteen estimated they had used the thermal sight a minimum of 50 times, and only two estimated having used it fewer than 30 times. Eight subjects tested the modified controls first, and then the unmodified; and eight tried the unmodified ones first and then the modified. The researchers did not attempt to conceal the purpose of the test from the subjects; rather, they were asked to adopt the role of critical experts in making their judgments. In the interest of clarity, the questions asked and the responses of the subjects are given together in the results section.

RESULTS

Contrast and Brightness Knobs

Before beginning the test, a researcher asked each subject whether he had "ever personally caught, knocked, or jarred the contrast or brightness knobs by mistake, so that they needed resetting?" Responses were recorded using a five-point scale, where 5 meant often, 3 meant occasionally, and 1 meant never. Only two of the 16 subjects said it had never happened to them; the median response was occasionally, and the single most frequent response was often (7 subjects). When asked whether they had ever found vehicle vibration to cause these controls to slip out of adjustment, 7 subjects replied never and the remaining 9 replied occasionally. While the sample used here is small, the results agree with initial reports and observations, which had suggested that the problem is prevalent.

In each vehicle, each subject was asked to rotate the contrast and brightness knobs and assess their freedom of rotation. Five descriptors were provided: very stiff, a little stiff, not easy to rotate, fairly easy to rotate, and very easy to rotate. In the vehicle with the unmodified knobs, 12 of the 16 subjects assessed them as very easy to rotate, 3 assessed them as fairly easy to rotate, and one said they were a little stiff. In the vehicle with the modified knobs, 15 of the 16 assessed the knobs as being a little stiff, and one said they were very stiff.

Subjects were then asked to run their fingers lightly, in a lateral motion, over the tops of the controls and to assess how easy or difficult it would be to move the controls by accident. Five descriptors were provided: very difficult, difficult, not easy, fairly easy, and very easy. In the vehicle with the unmodified knobs, 14 of the 16 subjects said it would be very easy to move them by accident and 2 said it would be not easy. In the vehicle with the modified controls, all 16 subjects said it would be difficult or very difficult.

Finally, in each vehicle, the subjects were asked whether they felt the contrast and brightness knobs should be made stiffer, left as they are, or made less stiff. In the vehicle with the unmodified knobs, there was unanimous agreement that the controls should be made stiffer. In the vehicle with the modified knobs, 14 of the 16 subjects said they should be left as they were, one said they should be made more stiff, and one that they should be made less stiff.

Night Sight Power/Boresight Switch

The 16 subjects were asked whether they had ever turned the night sight off by accident; twelve said that they had and four that they had not. Three of these four subjects were the three with the least experience of using the thermal sight. Only three subjects recalled ever turning the boresight lamp on by accident. But as one of them pointed out, since the BFV does not have an indicator to tell the gunner when the lamp is on (other than the switch position), he probably wouldn't have noticed if he had turned it on by accident.

Fourteen of the sixteen subjects stated that they felt a guard of some sort was needed. Eleven subjects felt the prototype guard would be useful, but the majority wanted either a switch that locked into position or a full cover that had to be lifted to expose the controls. In making these suggestions, the subjects were unaware of the design constraints adopted by the researchers in developing the solution.

During the test, researchers instructed the subjects to make repeated vertical downward hand movements across the face of the switch with the intent of switching it downward. Only one subject succeeded in doing so, and this was because the wrist band of his watch caught on it.

DISCUSSION

The findings reinforce the observation that the problem of accidental displacement of the contrast and brightness controls was prevalent. The modified controls were found to be much stiffer than the unmodified ones. There was total agreement among subjects that the modified controls would be difficult to displace accidentally, and general concurrence that the degree of stiffness achieved was sufficient. The degree of compression of the grommet was not measured in the test, nor is it germane; it was achieved by a medium thumb pressure on the knob face with one hand, while the allen screw was tightened with the other. The researchers strongly suspect that any reasonable degree of increase in stiffness of these controls would have been welcomed by the subjects, and would have elicited a similar pattern of responses. Moreover, if the modification is accepted, gunners would be able to modify stiffness to suit their own particular tastes.

One subject suggested that the contrast and brightness knobs should be of different shapes. This idea has merit. When gunners are using the sight, they frequently reach for controls and identify them by touch. At present, because the knobs are identical, a gunner may not always be certain that he has reached for the correct one. The addition of distinctive tactile feedback would alleviate this problem.

The test subjects generally agreed there is a real need for some sort of safeguard on the night sight/power switch (87.5 percent agreement). The prototype proved functional, but not 100 percent effective (one accidental activation in repeated tries by 16 subjects). Given the constraints that were accepted when formulating the design, the experimenters believe a half-guard, similar to the prototype tested, is a viable solution. Because such a guard has no moving parts, it should prove to be durable. And because it can be stamped out of sheet metal, it should be reasonably inexpensive to manufacture. As with the grommets, it is easy to install, requiring only a small adjustable wrench. Installation of a half-guard and the grommets can be accomplished by one man in under 30 minutes.

It is interesting to note that the platoon sergeant, who participated in the test and whose vehicles were used for the test, requested that the guard and grommets be left in place. Further, most of the test subjects also indicated that they would want to incorporate the modifications into their own BFVs as quickly as possible.

CONCLUSIONS AND RECOMMENDATIONS

The test clearly demonstrated the need for modifications to the ISU panel to limit the freedom of rotation of the contrast and brightness knobs. Based on these findings, the researchers concluded that the use of the grommets to provide a friction brake on the freedom of rotation of the contrast and brightness knobs would be beneficial and could be accomplished at minimal cost. This is a cheap, simple, and easy-to-install solution to a real and persistent problem. The suggestion of providing contrast and brightness knobs that give distinctively different tactile feedback warrants further exploration to determine utility of the solution and optimal knob shape.

The test also demonstrated the need and desire for a guard on the night sight on/off switch. The experimenters feel that a half-guard of the type described answers the need.

These modifications could be implemented in a number of BFVs and field tested for an extended period. If proven satisfactory, they should be recommended for installation on all BFVs.

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